George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

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Project Plan

for

Interstellar Precursor Propulsion (IPP)

In-Space Investment Area

ADVANCED SPACE TRANSPORTATION PROGRAM OFFICE (ASTP)
TD15

Interstellar Precursor Propulsion Project Plan
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INTERSTELLAR PRECURSOR PROPULSION PROJECT PLAN

SIGNATURE PAGE

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LIST OF ACRONYMS

AFRL	Air Force Research Laboratory
ASTP	Advanced Space Transportation Program
CDR	Critical Design Review
COTS	Commercial-Off-The-Shelf
EAA	Enterprise Associate Administrator
FDR	Final Design Review
FTE	Full Time Equivalent
FY	Fiscal Year
GFE	Government Furnished Equipment
GFP	Government Furnished Property
GPMC	Governing Program Management Council
IA	Independent Assessment
JSC	Johnson Space Center
NOA	New Obligational Authority
MSFC	Marshall Space Flight Center
MOA	Memorandum of Agreement
NASA	National Aeronautics and Space Administration
NPD	NASA Program Directive
NPG	NASA Procedures and Guidelines
NRA	NASA Research Agreement
PCA	Program Commitment Agreement
PDR	Preliminary Design Review
PMC	Program Management Council
SRR	System Requirements Review
STPO	Space Transportation Program Office
TBD	To Be Determined

FOREWORD

This Project Plan describes the objectives, requirements, and planning for the Interstellar Precursor Propulsion Project. This plan is consistent with the objectives, requirements, and plans documented in the ASTP Program Plan. This plan has been prepared in accordance with the *NASA Program and Project Management Processes and Requirements*, NPG 7120.5A, and is consistent with the *NASA Strategic Management Handbook* and *NASA Program/Project Management*, NPD 7120.4A. In addition, it follows the MSFC Lead Center Implementation Plan for Space Transportation System Development and Technology Programs.

I. INTRODUCTION

This project is an element of the NASA In-Space Investment Area managed under the Advanced Space Transportation Program (ASTP) at Marshall Space Flight Center (MSFC). The primary goal is to develop technologies to enable robust exploration of nearby interstellar space in support of proposed and planned interstellar precursor missions.

II. OBJECTIVES

The specific objective is to develop and test the propulsion elements for NASA's interstellar precursor missions. Two specific missions have been discussed. The first mission, Interstellar Probe, is to send a spacecraft to a distance of 250 astronomical units (AU) within 20 years of launch. The second mission proposed is a swift mission to rendezvous with a Kuiper Belt object. The Interstellar Probe is planned as a 2008 New Start, with in space technology demonstrations in the 2002-2005 timeframe. Success will be measured by successful development of technologies needed for precursors and follow-on interstellar missions, and the completion of demonstrations leading to the successful launch of the Interstellar Probe in 2011.

III. CUSTOMER DEFINITION AND ADVOCACY

The primary customers are NASA's Science Enterprise and Aeronautics and Space Transportation Technology Enterprise.

Customer advocacy will be achieved by a number of approaches including instituting cooperative arrangements with government agencies and industry partners who have synergistic goals. These agreements will provide for the timely release of data that may be beneficial to current and future space propulsion programs. The IPP Project will conduct periodic technology exhibitions to highlight ongoing technology efforts. Customer participation in establishment, review, and approval of requirements and in design reviews will be encouraged.

IV. PROJECT AUTHORITY

The NASA Strategic Plan and the NASA Strategic Management Handbook assign to MSFC the Lead Center responsibility for Space Transportation Systems development. The JPL is the lead center for the Interstellar Probe mission. The MSFC is lead for the propulsion elements of this and other interstellar missions. MSFC will obtain development support from GRC and JPL. The MSFC Program

Management Council (PMC) is responsible for oversight of the Interstellar Precursor Propulsion Project.

V. MANAGEMENT

A. Organization and Responsibilities

1. NASA Headquarters

Overall goals for the investment area will be established by NASA Headquarters and communicated to the project.

2. Field Centers

The field centers involved in the IPP include the George C. Marshall Space Flight Center, the Jet Propulsion Laboratory and the Glenn Research Center. The involvement of each center is described below:

a. George C. Marshall Space Flight Center (MSFC)

The project is managed under the MSFC Space Transportation Directorate (STD) in the Advance Space Transportation Program in the Interstellar Precursor Propulsion Project Office. The IPP Project Office consists of a Project Manager, a lead systems engineer, and a part-time resources person. Work will be performed at MSFC, GRC, and JPL, as well as in industry and academia. Internal MSFC project management will be assisted by the on-line secure Center Planning Resources System (CPRS) database as well as extensive use of Web based document storage in the Virtual Research Center, COTS project management software and email.

MSFC's Propulsion Research Center, Engineering Directorate and Science Directorate will all have personnel and facilities supporting the IPP in the areas of fission propulsion, high-power electric propulsion, environmental definition and testing, space plasma physics for innovative space plasma propulsion, etc.

b. Glenn Research Center (GRC)

GRC will be utilized in the area of high power electric thrusters.

c. Jet Propulsion Laboratory (JPL)

JPL will be utilized in the area of solar sails.

B. Responsibilities

1. ASTP Program Manager

The ASTP Program Manager is responsible for:

a) Program planning, including: recommendation of program objectives, requirements, implementation guidelines, program integration, budget and milestones, and preparation of Program Plans and supporting development of PCAs

b) Developing, recommending, and advocating the program resources

c) Execution of the Program Plan and oversight

d) Approving Project Plans and associated changes to these documents

e) Reviewing and reporting program/project performance

f) Establishing project requirements and performance metrics

g) Allocating budgets to projects

h) Controlling program changes

i) Establishing support agreements

j) Integrating the planning and execution of individual projects

k) Complying with applicable Federal law, regulations, Executive Orders, and Agency Directives

2) IPP Project Manager

The IPP Project Manager is responsible for:

a) Preparation and maintenance of the Project Plans, specifications, schedules, and budgets

b) Acquisition and utilization of participating contractors/industry partners

c) Execution of the Project Plan

d) Supporting program management and integration

e) Reporting project status and contractor/industry partner performance

f) Interfacing with NASA Centers, Headquarters, AFRL, other government and contractor personnel as required to ensure mission objectives are met

g) Complying with applicable Federal law, regulations, Executive Orders, and Agency Directives

VI. TECHNICAL SUMMARY

A. Project requirements

The project requirements are to develop materials, components, and complete propulsion systems to support a variety of approaches for building and flying interstellar precursor spacecraft. Because of the relative immaturity of these systems, initial work will focus on technology development, materials development and test, and key subsystem element fabrication and testing.

B. Systems requirements

The initial spacecraft systems envisioned might use Solar Sail or Nuclear-Electric propulsion. Emphasis will be given to development in these areas, although strong support will also be given to other promising technologies such as minimagnetospheric plasma propulsion and magnetic sails.

C. System Constraints

TBD

D. Ground Systems and Support

None.

E. Facilities

Existing facilities will be utilized at MSFC and supporting Centers.

F. Logistics

The IPP logistics activities will be integrated with other disciplines and functions to assure cost effective support for the project. Logistics planning and implementation will be tailored specifically to IPP project requirements.

G. Mission Results Analysis and Reporting

Technology results will be made available in a timely manner to customers, management and interested parties, as appropriate. NASA technical reports, conference and journal publication will be encouraged. Management at all relevant levels will be kept apprised of technical progress.

VII. MILESTONES

Milestones for the project include:

- 4QFY00 - Develop and test candidate solar sail microtruss fabrics
  - Output: Sample carbon fiber microtruss and characterization
  - Outcome: Low areal density fabric candidates for solar sail propulsion systems

- 4QFY00 - Develop physical models of the Minimagnetospheric Plasma Propulsion System
  - Output: Viability assessment of the propulsion concept and its applicability for propulsion
  - Outcome: Decision for/against further development funding

- 4QFY01 - Define a solar sail film architecture
  - Output: Recommendations of architecture and attachment method(s)
  - Outcome: Design drivers for sail fabrication and assembly

VIII. RESOURCES

A. Funding Requirements (NOA in Millions)

FY99	FY00	FY01	FY02	FY03	TOTALS
0	1.0	0	0	0	1.0

B. Institutional Requirements (FTE*)

FY99	FY00	FY01	FY02	FY03	TOTALS
0	5.6	0	0	0	5.6

* MSFC Only

IX. CONTROLS

The IPP Project controls start with the Program Commitment Agreement (PCA) for the ASTP Program. The PCA is interpreted at every level to meet the NASA commitment and reflected in the technical, schedule and cost requirements imposed on each of the projects.

A. NASA Headquarters

The ASTP PCA establishes the top level technical, schedule, and cost controls placed on the program.

B. Marshall Space Flight Center

The ASTP Program Plan and this Project Plan outline the technical, schedule and cost commitments of the IPP Project.

C. Change Controls

Proposed changes to project plans shall be submitted to the ASTP Program Manager for approval. Impacts to cost, schedule, and technical performance shall be included.

D. Interface Controls

Interfaces and issues among the several STD programs are controlled by the Level II Board, chaired by the STD Manager. Interfaces between the IPP project elements are controlled by the IPP Project Manager.

E. Project Plan Updates

The IPP Project Plan updates will occur as required to reflect project changes. Annually, the IPP Project Plan will be assessed by the IPP Project Office to determine if updates are warranted. If appropriate, updates will be incorporated and will be coordinated with the ASTP Program Manager for concurrence.

X. IMPLEMENTATION APPROACH

The IPP will be implemented using standard NASA practices and approaches following accepted guidelines.

XI. ACQUISITION SUMMARY

The IPP experiment acquisition strategy is based on both NASA in-house and contracted activities. All of the planned individual contracts are currently anticipated to be less than $100M. Because of the experimental nature of the IPP existing contracts, NASA Research Announcements, Purchase Orders, and Support Agreements will be utilized to the greatest extent possible.

XII. PROGRAM/PROJECT DEPENDENCIES

Some technology areas being developed by the IPP are synergistic with those being developed by The Office of Space Science. Working relationships with participating centers will be maintained.

XIII. AGREEMENTS

A. Internal NASA Agreements

MSFC is the Lead Center for Interstellar Propulsion Research. IPP will require significant coordination between MSFC and other participating Centers. Coordination on specific technology development activities will be dictated by circumstances on an as-needed basis.

B. External Agreements

None.

XIV. PERFORMANCE ASSURANCE

Quality

IPP flight hardware designed, developed and built in-house at MSFC will be in accordance with the MPG 144.1. In-house hardware may be built to dated drawings with the approval of the Lead Systems Engineer, as specified in the IPP Configuration Control Plan. As built drawings will be submitted to the MSFC Configuration Control Process as specified in the IPP Configuration Control Plan.

Due to the limited scope of the IPP flight demonstration experiments, flight hardware may be commercial off-the-shelf as long as it meets the requirements specified in the IPP Systems Specification.

IPP flight hardware purchased from outside vendors is not required to be ISO 9000 compliant. IPP flight hardware purchased from outside vendors will be based on the specific requirements of NHB 5300.4(1C). Tailoring of these requirements will be reflected in the IPP Quality Plan and/or in the vendor purchase order/contract.

IPP flight hardware purchased from outside vendors must be delivered with a Certificate of Compliance (COC) and an acceptance data package as specified in the purchase order or contract.

XV. RISK MANAGEMENT

A Risk Management Plan will be developed for IPP flight hardware. This plan will document a continuous process that:

- identifies risks
- analyzes their impact and prioritizes them

- develops and carries out plans for risk mitigation, acceptance, or other action
- tracks risks and the implementation of mitigation plans
- supports informed, timely, and effective decisions to control risks and mitigation plans
- assures that risk information is communicated among all levels of the project

Risk management begins in the formulation phase with an initial risk identification and development of a Risk Management Plan and continues throughout the product's life cycle through the disposition and tracking of existing and new risks.

XVI. ENVIRONMENTAL IMPACT

Environmental impact assessment(s) shall be developed as needed by the appropriate center(s) Environmental Engineering and Management Office(s).

XVII. SAFETY

The IPP Project will develop safety guidelines, as appropriate, to provide for the early identification, analysis, reduction, and/or elimination of hazards that might cause the following:

- Loss of life or injury/illness to personnel
- Damage to or loss of equipment or property (including software)
- Unexpected or collateral damage as a result of tests
- Failure of mission
- Loss of system availability
- Damage to the environment

If required, the IPP Project will develop a safety plan that details such activities as system safety, reliability engineering, electronic and mechanical parts reliability, quality assurance for both hardware and software, surveillance of the development processes, "closed loop" problem failure reporting and resolution, environmental design and test requirements. The plan shall be developed early in the project formulation process for each task, as required. Mission success criteria shall be defined to aid in early assessment of the impact of risk management trade-off decisions. The safety and mission success activity shall accomplish the following:

- Provide for formal assessment and documentation of each hazard, with risks identified, analyzed, planned, tracked, and controlled.
- Provide for a safety assessment and certification regarding readiness for flight or operations, explicitly noting any exceptions arising from safety issues and concerns.
- Utilize a quality management system governed by the ISO 9000 standard, appropriate surveillance, and NASA Engineering and Quality Audit (NEQA) techniques.

XVIII. TECHNOLOGY ASSESSMENT

Ongoing assessment of needs for technology will be conducted by project management to insure that long term goals can be met.

XIX. COMMERCIALIZATION

Many of the technologies to be demonstrated may have eventual commercial application.

XX. REVIEWS

A. Management Reviews

Management reviews will be scheduled during the life of the project. The type and frequency of the reviews will be established according to the project unique needs and requirements. Reviews will be scheduled to keep center, program and project management informed of the current status of existing or potential problem areas. Agency management will be informed, in advance, of the schedule and agenda of the major reviews and will be invited to participate at their discretion. Special reviews by any level of management will be scheduled when the need arises.

1. Lead Center Program Management Council (PMC) Review

The Marshall Space Flight Center lead center PMC will review the IPP Project annually. The reviews will cover overall status information, including schedule, change, performance, funding, interfaces coordination, and other management and technical topics. The Lead Center PMC review will also assess project progress against metrics and criteria proposed in procurement instruments.

2. Quarterly Program Review

A quarterly program review will be held to review cost, schedule, and technical issues. The location of the review will be determined on a case-by-case basis. Participants will include, as a minimum, the program managers of the ASTP and STD offices.

3. Other Reviews

Other independent reviews will be scheduled as required.

B. Technical Reviews

Each technology development effort will be reviewed at six-month increments to assess progress. Decisions for continuation, redirection, and/or cancellation will be made at that time.

XXI. TAILORING

The requirements of NASA Policy Directive (NPD) 7120.4A and NASA Procedures and Guidelines (NPG) 7120.5A apply to this program as tailored by the ASTP Program Plan.

XXII. RECORDS RETENTION

The IPP Project Manager will determine which project records will be retained and for how long in order to ensure a permanent record of the project and lessons learned are available to benefit future NASA projects.

XXIII. CHANGE LOG

EFF. DATE	STATUS	DOC. REVISION	DESCRIPTION
Dec 13, 1999	Baseline	-	Initial issue